ADTF: AN ADVANCED ACCELERATOR FACILITY FOR NUCLEAR TECHNOLOGY TESTING

Michael W. Cappiello
Los Alamos National Laboratory
P.O. Box 1663 MS H816
Los Alamos, New Mexico 87545
(505) 665-6408

ABSTRACT

As the centerpiece of the Advanced Accelerator Applications (AAA) Program, the ADTF provides a world-class accelerator-driven test facility to demonstrate technologies for the transmutation of spent nuclear fuel and waste, to provide a test bed for advanced nuclear technologies and applications, and to demonstrate technologies pertinent to a robust tritium backup capability. For the transmutation mission, the principal mechanism to achieve success will be through proof-of-performance/proof-of-practicality demonstrations. An accelerator-driven spallation target and adjacent subcritical multiplier will provide a prototypic environment to perform these demonstrations. This unique environment will also be used to conduct materials research and research in conventional nuclear engineering science applications. The accelerator developed for the facility will provide a continuous 600-MeV proton beam up to 13 mA to a central spallation neutron source. The neutron source will drive a subcritical multiplier that provides an irradiation environment representative of reference transmutation systems. Fuels, materials, and overall transmutation reduction factors will be demon-

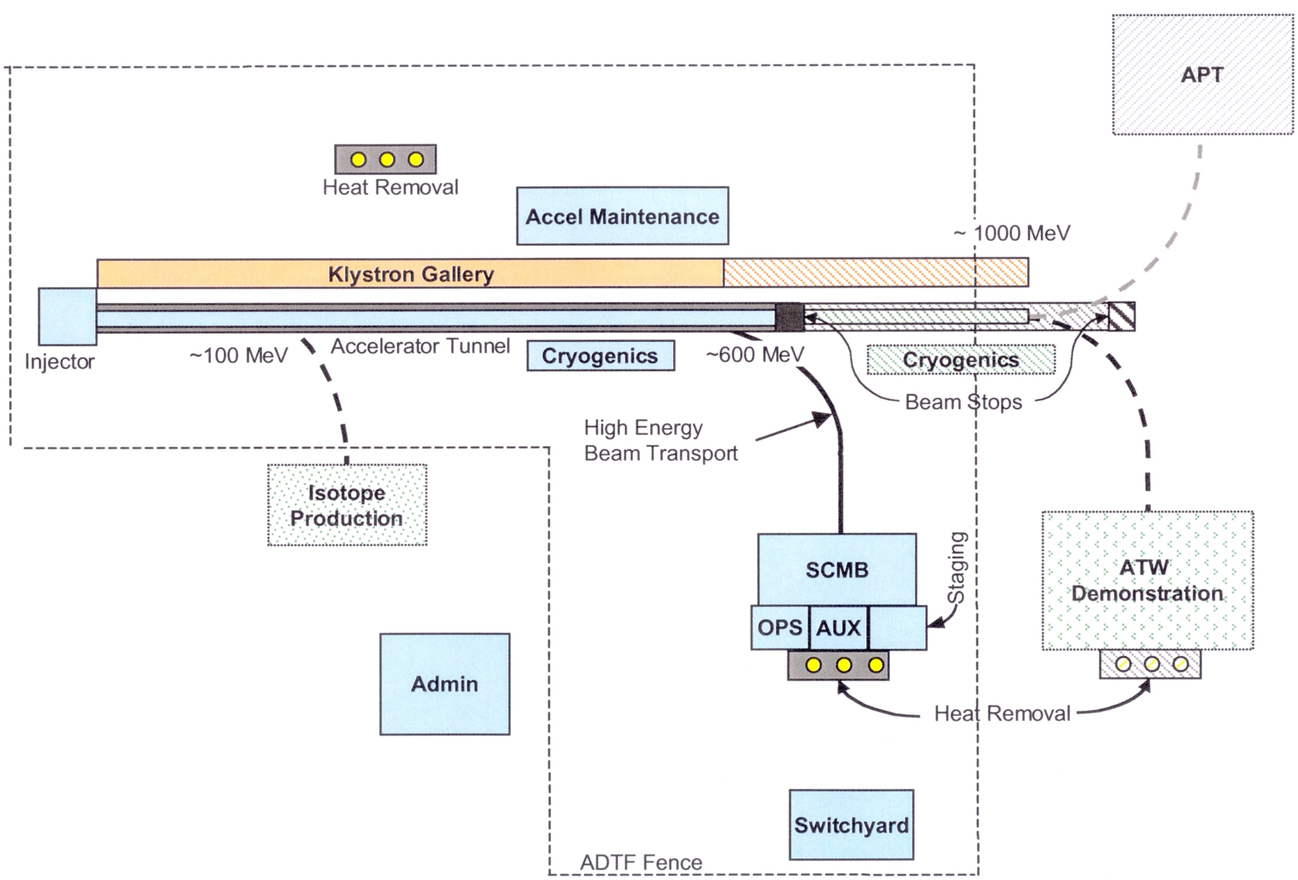

Figure 1. ADTF site layout.

strated. The accelerator will be upgradeable to approximately 1000 MeV, 100 mA to perform a tritium back-up mission, if the need arises.

To demonstrate the technologies necessary for the transmutation mission, the high-level requirements to meet this mission are:

- Flux levels sufficient to test fuel irradiation behavior and fission product target burnup performance;
- Conditions that will allow a meaningful level of recycling of nuclear transmutation fuel so as to demonstrate low-loss separations and fuel fabrication process operations that would be required in an Accelerator Transmutation of Waste (ATW) or any other transmutation system;
- Coupling between a spallation target and a subcritical multiplying blanket to allow physics tests, the development and demonstration of system control, and the demonstration of system safety; and
- Operation of the accelerator drive in modes to reduce fast, accelerator-induced transients to levels representative of ATW system operation.

The neutron source envisioned for the ADT Facility would be produced by a high-power (5–10 megawatt range), continuous proton beam impinging upon a heavy-metal spallation target (tungsten or lead-bismuth eutectic). At present an accelerator energy of 600 MeV seems most appropriate in terms of cost and performance. The neutron source will drive a subcritical multiplier that provides an irradiation environment representative of reference transmutation systems as described above. The primary facility segments include a linear accelerator, beam transport, a target/multiplier, a hot cell capability for fuels and irradiated materials handling and inspection, and other balance-of-facility components.

Illustrative accelerator and target/multiplier performance characteristics are summarized in Table 1. These characteristics satisfy general facility performance requirements.

SITING

The site chosen for the ADTF will allow for expansion to accommodate future construction of a large-scale ATW demonstration plant or a target station with the capability for tritium production. In addition, space will be available for a separate isotope production target station that can be built with private funds. These potential upgrades will be considered to occur either sequentially or concurrently, and construction tie-ins to the ADTF will be provided to minimize interference between ADTF operation and new construction activities. The scope of ADTF excludes the facilities needed for new fuel fabrication and chemical separation of spent fuels. The site-selection process will, however, evaluate the economics of siting ADTF in proximity to existing Department of Energy (DOE) facilities that can perform these functions or, alternatively, transportation costs if the ADTF is remote from these facilities.

Given favorable support from DOE and Congress, the ADTF project will be executed in a period of less than 10 years, from Approval of Mission Need to Approval to Commence Operations. The ADTF's total project cost, which includes all design, construction, start-up, and related engineering development and demonstration, will be less than $1.5 billion. The environment, safety, and health risk to the public will be equal to or less than advanced reactors.

Table 1. ADT Facility Preconceptual Performance Characteristics

Parameter	Value
Accelerator Beam Power	4 to 8 MW
Proton energy	600 MeV
Proton current	Nominally 6 to 13 mA
Multiplier Thermal Power	20 MW expandable later to up to 100 MW
Multiplier effective multiplication constant	0.8 to 0.97, consistent with meeting safety objectives
Flux Level Goal	Greater than 0.1 MeV: 3×10^{15} n/cm^2/s
Test Fuel Throughput	Approximately 50 kg/year
Material Irradiation Environment	Window: Typical of operating ATW environments (30-100 uA/cm^2 protons) Blanket: Typical of operating ATW environments (40-50 dpa/y, 75-80 appm/y H production, and 5-10 appm/y He production)
Target Material	Tungsten or Lead-Bismuth Eutectic